

SEAMLESS CIRCULAR STEEL TUBES MECHANICAL & GENERAL ENGINEERING PURPOSES

BS EN 10297-1:2003

Technical delivery conditions for non-alloy and alloy steel tubes

STEEL GRADES**CHEMICAL COMPOSITION****MECHANICAL PROPERTIES****DIMENSIONS & TOLERANCES****INSPECTION & TESTING****HEAT TREATMENT DATA**

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REFERENCE NOTE

Source dimensional values and footnotes are retained. Confirm the applicable material, grade, schedule and project specification before ordering.

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Foreword

This document (EN 10297-1:2003) has been prepared by Technical Committee ECISS /TC 29, "Steel tubes and fittings for steel tubes" the secretariat of which is held by UNI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2003, and conflicting national standards shall be withdrawn at the latest by August 2003.

In this European Standard the annexes A, C, D and E are normative and annex B is informative.

Another Part of EN 10297 in course of preparation is :

— Part 2 : *Stainless steel tubes*

Another European Standard series covering welded tubes for mechanical and general engineering purposes is currently being prepared.

prEN 10296, *Welded circular steel tubes for mechanical and general engineering purposes — Technical delivery conditions*.

Other European Standard series being prepared in this area are prEN 10294 for hollow bars for machining and prEN 10305 for steel tubes for precision applications.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This Part of EN 10297 specifies the technical delivery conditions for seamless circular tubes made of non-alloy and alloy steels for mechanical and general engineering purposes.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 10002-1, *Metallic materials — Tensile testing — Part 1: Method of test at ambient temperature.*

EN 10020, *Definition and classification of grades of steel.*

EN 10021, *General technical delivery requirements for steel and iron products.*

EN 10027-1, *Designation systems for steel — Part 1: Steel names, principal symbols.*

EN 10027-2, *Designation systems for steel — Part 2: Numerical system.*

EN 10045-1, *Metallic materials — Charpy Impact test — Part 1: Test method.*

EN 10052, *Vocabulary of heat treatment terms for ferrous products.*

prEN 10168, *Iron and steel products — Inspection documents — List of information and description.*

EN 10204, *Metallic products — Types of inspection documents.*

EN 10220, *Seamless and welded steel tubes - General tables of dimensions and masses per unit length.*

EN 10246-1, *Non-destructive testing of steel tubes — Part 1: Automatic electromagnetic testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for verification of hydraulic leak-tightness.*

EN 10246-3, *Non-destructive testing of steel tubes — Part 3 : Automatic eddy current testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of imperfections.*

EN 10246-5, *Non-destructive testing of steel tubes — Part 5 : Automatic full peripheral magnetic transducer/flux leakage testing of seamless and welded (except submerged arc-welded) ferromagnetic steel tubes for the detection of longitudinal imperfections.*

EN 10246-7, *Non-destructive testing of steel tubes — Part 7 : Automatic full peripheral ultrasonic testing of seamless and welded (except submerged arc-welded) steel tubes for the detection of longitudinal imperfections.*

EN 10256, *Non-destructive testing of steel tubes — Qualification and competence of level 1 and 2 non-destructive testing personnel.*

CR 10260:1998, *Designation systems for steel - Additional symbols.*

prEN 10266, *Steel tubes, fittings and structural hollow sections — Symbols and definition of terms for use in product standards.*

EN ISO 377, *Steel and steel products — Location and preparation of samples and test pieces for mechanical testing (ISO 377:1997).*

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EN ISO 642, *Steel — Hardenability test by end quenching (Jominy test) (ISO 642:1999).*

EN ISO 2566-1, *Steel — Conversion of elongation values — Part 1: Carbon and low alloy steels (ISO 2566-1:1984).*

EN ISO 6506-1, *Metallic materials - Brinell hardness test — Part 1: Test method (ISO 6506-1:1999).*

EN ISO 6508-1:1999, *Metallic materials - Rockwell hardness test — Part 1 : Test method (scales A, B, C, D, E, F, G, H, K, N, T) (ISO 6508-1:1999).*

EURONORM 103, *Micrograph determination of the ferritic or austenitic grain size of steels.*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN 10020, EN 10021, EN 10052 and prEN 10266 and the following terms and definitions apply.

3.1

fine grain steel

steel having an austenitic/ferritic grain size equal to or finer than 6 when measured in accordance with EURONORM 103

3.2

normalizing rolling

a rolling process in which the final deformation is carried out in a certain temperature range leading to a material condition equivalent to that obtained after normalizing so that the specified values of the mechanical properties are retained even after normalizing (+N)

NOTE Delivery condition of tubes manufactured by a normalizing rolling process or normalized by heat treatment in a furnace are both identified with the same symbol.

3.3

as rolled

formed after heating into the austenitic region (i.e. above AC 3) without subsequent heat treatment (+AR)

3.4

annealing

heat treatment at a temperature slightly below AC 1 (+A)

3.5

TH treatment

heat treatment with the object of achieving a hardness within a specified range (+TH)

3.6

FP treatment

heat treatment with the object of producing a ferritic and pearlitic structure and achieving a hardness within a specified range (+FP)

3.7

employer

organization for which the person works on a regular basis

NOTE The employer may be either the tube manufacturer or a third party organization providing non-destructive testing (NDT) services.

4 Symbols

See prEN 10266 and CR 10260.

5 Classification and designation

5.1 Classification

In accordance with EN 10020 the grades in Tables 3, 4, 5, 6 and A1 are classified as given in Table 1.

5.2 Designation

For tubes covered by this Part of this European Standard the steel designation consists of:

— the number of this Part of this European Standard (EN 10297-1) ;

plus either :

— the steel name in accordance with EN 10027-1 and CR 10260 ;

or

— the steel number allocated in accordance with EN 10027-2.

These are given in Table 1.

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Table 1 — Classification of steel grades and delivery condition

Steel grade		Normal delivery condition ^a	Classification in accordance with EN 10020
Steel name	Steel number		
E235	1.0308	+AR or +N	Non-alloy quality steel
E275	1.0225		
E315	1.0236		
E355	1.0580		
E470	1.0536	+AR	
E275K2	1.0456	+N	Alloy quality steel
E420J2	1.0599		
E355K2	1.0920		
E460K2	1.8891	+N	Alloy special steel
E590K2	1.0644	+QT	Non-alloy special steel
E730K2	1.8893	+QT	Alloy special steel
C22E	1.1151	+N or +QT	Non-alloy special steel
C35E	1.1181		
C45E	1.1191		
C60E	1.1221		
38Mn6	1.1127		
41Cr4	1.7035	+QT	Alloy special steel
25CrMo4	1.7218		
30CrMo4	1.7216		
34CrMo4	1.7220		
42CrMo4	1.7225		
36CrNiMo4	1.6511		
30CrNiMo8	1.6580		
41NiCrMo7-3-2	1.6563		
C10E	1.1121	+A, +TH, +FP, +N	Non-alloy special steel
C15E	1.1141		
C15R	1.1140		
16MnCr5	1.7131		Alloy special steel
16MnCrS5	1.7139		
20NiCrMo2-2	1.6523		
20NiCrMoS2-2	1.6526		

^a At the discretion of the manufacturer, the tube may be cold finished. The tube shall then be annealed or normalized, to achieve the required properties.

6 Information to be supplied by the purchaser

6.1 Mandatory information

The following information shall be supplied by the purchaser at the time of enquiry and order :

- 1) the quantity (mass or total length or number);

- 3) the dimensions (outside diameter, wall thickness) (see 8.9.1);
- 4) the designation according to this Part of this European Standard (see 5.2);
- 5) the delivery condition (see 7.3.1).

6.2 Options

A number of options are specified in this Part of this European Standard, and are listed as follows with appropriate clause references. In the event that the purchaser does not indicate his wish to implement any of these options at the time of enquiry and order the tube shall be supplied in accordance with the basic specification (See 6.1).

- 1) Descaling (see 7.3.1);
- 2) tensile test on sample in condition +N (see 8.3.2);
- 3) tensile test on sample in condition +QT (see 8.3.3);
- 4) tensile test (see 8.3.4);
- 5) impact energy values of Table 13 (see 8.3.5);
- 6) hardness range (see 8.4.2);
- 7) hardness test (see 8.4.3);
- 8) hardenability requirements of Annex D (see 8.5);
- 9) verification of hardenability (see 8.5);
- 10) verification of hardenability by test (see 8.5);
- 11) non-destructive testing (see 8.6.2);
- 12) leak tightness test (see 8.6.2);
- 13) exact lengths (see 8.9.2);
- 14) specific inspection for tubes made of steels from Table 3 (see 9.1);
- 15) inspection document 2.2 (see 9.2.1);
- 16) inspection document 3.1.A, 3.1.C or 3.2 (see 9.2.1);
- 17) hardenability test on a test piece taken from a sample tube (see 11.3);
- 18) supplied tubes shall not contain areas prepared and used for hardness test (see 11.4);
- 19) selection of the leak tightness test method by the purchaser (see 11.5.1);
- 20) coating for transit and storage (see clause 13).

6.3 Example of an order

Twenty five tonnes of tube in accordance with EN 10297-1 with specified outside diameter of 60,3 mm and specified wall thickness of 3,6 mm grade E275 steel in the normalised delivery condition and supplied with specific inspection.

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25 t Tube - - 60,3 x 3,6 - EN 10297 - E275 - +N - Option 14

7 Manufacturing process**7.1 Steelmaking process**

The steelmaking process is at the discretion of the manufacturer.

Elements not included in Tables 3, 4, 5, 6 and A1 for the relevant grade shall not be intentionally added to the steel without the agreement of the purchaser, except for elements which may be added for finishing the cast. All appropriate measures shall be taken to prevent the addition of undesirable elements from scrap or other materials used in the steelmaking process.

7.2 Deoxidation process

Steels shall be fully killed and additionally those in Tables 4 and 5 shall contain N binding elements and are fine grain steels.

7.3 Tube manufacture and delivery conditions

7.3.1 Tubes shall be manufactured by a seamless process.

Table 2 gives a summary of delivery conditions, hardenability requirements and related mandatory and optional test requirements for mechanical properties and hardness. For hardenability requirements see 8.5.

Tubes made of steels in Table 3 with the exception of E470 are normally supplied as rolled or normalized at the discretion of the manufacturer. However the purchaser may specify +N condition. Grade E470 is supplied as rolled.

Tubes made of steels in Table 4 are supplied in the delivery condition indicated in Table 9.

Tubes made of steels in Tables 5, 6 and A1 are supplied in a delivery condition indicated in Table 2 as specified by the purchaser.

The recommended heat treatment temperatures are given in Table B.1 and Table B.2 as appropriate.

At the manufacturers discretion tube may be cold finished, before the specified heat treatment is given. Cold finished tubes in the +AR condition shall be annealed or normalized to achieve the specified properties.

NOTE The cold drawing process leaves residual oil on the tube which may leave a residue when heat treated.

When specified the tubes shall be supplied descaled (see option 1). The amount of descaling shall be agreed at the time of enquiry and order. The method is at the discretion of the manufacturer.

Option 1 : Tubes shall be supplied descaled.

7.3.2 All NDT activities shall be carried out by qualified and competent level 1, 2 and/or 3 personnel authorised to operate by the employer.

The qualification shall be in accordance with EN 10256 or, at least an equivalent to it.

It is recommended that the level 3 personnel be certified in accordance with EN 473 or, at least an equivalent to it.

The operating authorisation issued by the employer shall be in accordance with a written procedure.

NDT operations shall be authorised by a level 3 NDT individual approved by the employer.

NOTE The definition of level 1, 2 and 3 can be found in appropriate standards, e.g. EN 473 and EN 10256.

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Table 2 — Summary of delivery conditions, related options and requirements

Applicable Table(s)	Applicable Table(s)	Delivery condition	Hardenability requirement	Test requirements ^a						
				Cast analysis	Tensile test			Impact test	Hardenability verification or test	Hardness test
					Standard condition	Simulated +N condition	Simulated +QT condition			
Tables 3 and 8		+AR ^b	-	M	M	-	-	-	-	-
		+N	-	M	M	-	-	-	-	-
Tables 4 and 9		+N	-	M	M	-	-	M	-	-
		+QT	-	M	M	-	-	M	-	-
Table 5	-	+AR	Option 8	M	-	Option 2	Option 3	-	Option 9 or 10	-
	10	+N	Option 8	M	M	-	Option 3	-	Option 9 or 10	-
	11	+QT		M	M	-	-	Option 5	-	Option 6
	-	+A	Option 8	M	Option 4	Option 2	Option 3	-	Option 9 or 10	M
Table 6	-	+AR ^c	Option 8	M	-	-	Option 3	-	Option 9 or 10	-
	12	+QT		M	M	-	-	Option 5	-	Option 6
	-	+A	Option 8	M	Option 4	-	Option 3	-	Option 9 or 10	M
Table A.1		+AR	Option 8 ^d	M	-	-	-	-	Option 9 or 10	-
		+N	Option 8 ^d	M	Option 4	-	-	-	Option 9 or 10	Option 7
		+A	Option 8 ^d	M	Option 4	-	-	-	Option 9 or 10	M
		+TH ^e	Option 8 ^d	M	Option 4	-	-	-	Option 9 or 10	M
		+FP ^e	Option 8 ^d	M	Option 4	-	-	-	Option 9 or 10	M

^a M = Mandatory, - = Not applicable.^b At the manufacturers discretion as rolled or normalized except for grade E 470 which is always supplied in +AR condition.^c +AR condition only applies for 25CrMo4 and 34CrMo4.^d Option 8 only applies for alloy special steels.^e +TH and +FP only apply for 16MnCr5, 16MnCrS5, 20NiCrMo2-2 and 20NiCrMoS2-2.

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8 Requirements

8.1 General

Tubes, when supplied in a delivery condition indicated in 7.3.1 and inspected in accordance with clause 9, shall conform to the requirements of this Part of this European Standard.

In addition the general technical delivery requirements specified in EN 10021 apply.

8.2 Chemical composition

The cast analysis reported by the steel producer shall apply and shall conform to the requirements of Tables 3, 4, 5, 6 and Table A.1.

In case of dispute the permissible deviations of a product analysis from the limits on cast analysis specified in Tables 3, 4, 5, 6 and Table A.1 are given in Table 7.

NOTE When welding tubes produced according to this part of EN 10297, account should be taken of the fact that the behaviour of the steel during and after welding is dependent not only on the steel and the delivery condition but also on the conditions of preparing for and carrying out welding. Not all of the steels specified in this standard are able to be welded unless specialised techniques are employed by specialist welders.

Table 3 — Chemical composition (cast analysis) for non-alloy quality steel, in % by mass ^a

Steel grade		C		Si		Mn		P	S	Other elements
Steel name	Steel number	min.	max.	min.	max.	min.	max.	max.	max.	
E235	1.0308		0,17	-	0,35	-	1,20	0,030	0,035	
E275	1.0225		0,21	-	0,35	-	1,40	0,030	0,035	
E315	1.0236		0,21	-	0,30	-	1,50	0,030	0,035	
E355 ^b	1.0580		0,22	-	0,55	-	1,60	0,030	0,035	
E470	1.0536	0,16	0,22	0,10	0,50	1,30	1,70	0,030	0,035	Al min 0,010, N max. 0,020, Nb max. 0,07, V 0,08/0,15
^a See also 7.1.										
^b Additions of Nb, V and Ti are permitted at the discretion of the manufacturer, the content of these elements shall be reported.										

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Table 4 — Chemical composition (cast analysis) for tubes with specified impact properties in % by mass^a

Steel grade		C		Si		Mn		P	S	Cr	Mo		Ni		Al	Cu	N	Nb	Ti	V	
		min.	max.	min.	max.	min.	max.	max.	max.	max.	min.	max.	min.	max.	Total ^b	max.	max.	max.	max.	min.	max.
Steel name	Steel number																				
E275K2	1.0456	-	0,20	-	0,40	0,50	1,40	0,030	0,030	0,30	-	0,10	-	0,30	0,020	0,35	0,015	0,05	0,03	-	0,05
E355K2	1.0920	-	0,20	-	0,50	0,90	1,65	0,030	0,030	0,30	-	0,10	-	0,50	0,020	0,35	0,015	0,05	0,05	-	0,12
E420J2	1.0599	0,16	0,22	0,10	0,50	1,30	1,70	0,030	0,035	0,30	-	0,08	-	0,40	0,010	0,30	0,020	0,07 ^c	0,05	0,08	0,15 ^c
E460K2	1.8891	-	0,20	-	0,60	1,00	1,70	0,030	0,030	0,30	-	0,10	-	0,80	0,020	0,70	0,025	0,05 ^c	0,05	-	0,20 ^c
E590K2	1.0644	0,16	0,22	0,10	0,50	1,30	1,70	0,030	0,035	0,30	-	0,08	-	0,40	0,010	0,30	0,020	0,07 ^c	0,05	0,08	0,15 ^c
E730K2	1.8893	-	0,20	-	0,50	1,40	1,70	0,025	0,025	0,30	0,30	0,45	0,30	0,70	0,020	0,20	0,020	0,05	0,05	-	0,12
^a See also 7.1.																					
^b If sufficient other N-binding elements are present the minimum total Al content does not apply.																					
^c Nb + V = 0,20 % max.																					

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Table 5 — Chemical composition (cast analysis) for tubes made of non-alloy special steels in % by mass^{a b}

Steel grade		C		Si		Mn		P	S
Steel name	Steel number	min.	max.	min.	max.	min.	max.	max.	max.
C22E	1.1151	0,17	0,24	-	0,40	0,40	0,70	0,035	0,035
C35E	1.1181	0,32	0,39	-	0,40	0,50	0,80	0,035	0,035
C45E	1.1191	0,42	0,50	-	0,40	0,50	0,80	0,035	0,035
C60E	1.1221	0,57	0,65	-	0,40	0,60	0,90	0,035	0,035
38Mn6	1.1127	0,34	0,42	0,15	0,35	1,40	1,65	0,035	0,035

^a See also 7.1.

^b Cr max. 0,40%, Mo max. 0,10%, Ni max 0,40%, Cr + Mo + Ni max. 0,63%.

Table 6 — Chemical composition (cast analysis) for tubes made from alloy special steels in % by mass^a

Steel grade		C		Si	Mn		P	S	Cr		Mo		Ni	
Steel name	Steel number	min.	max.	max.	min.	max.	max.	max.	min.	max.	min.	max.	min.	max.
41Cr4	1.7035	0,38	0,45	0,40	0,60	0,90	0,035	0,035	0,90	1,20	-	-	-	-
25CrMo4	1.7218	0,22	0,29	0,40	0,60	0,90	0,035	0,035	0,90	1,20	0,15	0,30	-	-
30CrMo4	1.7216	0,27	0,34	0,35	0,35	0,60	0,035	0,035	0,80	1,15	0,15	0,30	-	-
34CrMo4	1.7220	0,30	0,37	0,40	0,60	0,90	0,035	0,035	0,90	1,20	0,15	0,30	-	-
42CrMo4	1.7225	0,38	0,45	0,40	0,60	0,90	0,035	0,035	0,90	1,20	0,15	0,30	-	-
36CrNiMo4	1.6511	0,32	0,40	0,40	0,50	0,80	0,035	0,035	0,90	1,20	0,15	0,30	0,90	1,20
30CrNiMo8	1.6580	0,26	0,34	0,40	0,30	0,60	0,035	0,035	1,80	2,20	0,30	0,50	1,80	2,20
41NiCrMo7-3-2 ^b	1.6563	0,38	0,44	0,30	0,60	0,90	0,025	0,025	0,70	0,90	0,15	0,30	1,65	2,00

^a See also 7.1.

^b ≤ 0,25% Cu.

Table 7 — Permissible deviations of the product analysis from the specified limits on cast analysis

Element	Limiting values for the specified analysis % by mass	Permissible deviation on the product analysis % by mass
C	$\leq 0,55$	$\pm 0,02$
	$> 0,55 \leq 0,65$	$\pm 0,03$
Si	$\leq 0,60$	$\pm 0,05$
Mn	$\leq 1,70$	$- 0,05 / + 0,10$
P	$\leq 0,035$	$+ 0,005$
S	$\leq 0,040$	$+ 0,005$
Cr	$\leq 2,00$	$\pm 0,05$
	$> 2,00 \leq 2,20$	$\pm 0,10$
Mo	$\leq 0,30$	$\pm 0,03$
	$> 0,30 \leq 0,50$	$\pm 0,04$
Ni	$\leq 2,00$	$\pm 0,05$
	$> 2,00 \leq 2,20$	$\pm 0,07$
Al total	$\geq 0,010$	$- 0,005$
Cu	$\leq 0,35$	$+ 0,04$
	$> 0,35 \leq 0,70$	$+ 0,07$
N	$\leq 0,025$	$+ 0,002$
Nb	$\leq 0,07$	$+ 0,01$
Ti	$\leq 0,050$	$+ 0,01$
V	$\leq 0,20$	$\pm 0,02$

8.3 Mechanical properties

8.3.1 For tubes made of steels covered by Tables 3, 4, 5, and 6 the mechanical properties for the relevant delivery condition in Tables 8, 9, 10, 11 and 12 apply.

8.3.2 When specified, for tubes supplied as rolled or annealed in grades of Table 5 the mechanical properties in Table 10 shall apply for a sample submitted to a simulated normalizing treatment (see Option 2).

Option 2 A tensile test shall be carried out on a sample test piece from a sample heat treated to the condition +N and the results reported.

8.3.3 When specified, for tubes supplied normalized in grades of Table 5 and for tubes supplied as rolled or annealed in grades of Table 5 and 6 the mechanical properties in Table 12 shall apply for a sample submitted to a simulated quenched and tempered treatment (see Option 3).

Option 3 A tensile test shall be carried out on a sample test piece from a sample heat treated to the condition +QT and the results reported.

8.3.4 When specified for tubes supplied annealed in grades of Tables 5, 6, and Table A.1 or for tubes supplied in delivery condition +N, +TH or +FP in grades of Table A1 a tensile test shall be carried out and the results reported (see Option 4).

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Option 4 A tensile test shall be carried out and the results reported.

8.3.5 When specified for tubes supplied quenched and tempered in grades of Table 5 or 6 except C60E the impact properties, shown in Table 13 shall apply (see Option 5).

Option 5 The impact energy values of Table 13 shall be verified and the results reported.

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Table 8 — Mechanical properties for tubes made of steels in accordance with Table 3

Steel grade		Delivery condition	Minimum tensile properties										
Steel name	Steel number		Yield strength (R_{eH})					Tensile strength (R_m)				Elongation A	
			Mpa ^b					MPa				%	
			For T in mm					For T in mm				l	t
≤ 16	> 16 ≤ 40	> 40 ≤ 65	> 65 ≤ 80	> 80 ≤ 100	≤ 16	> 16 ≤ 40	> 40 ≤ 65	> 65 ≤ 100					
E 235	1.0308	+AR or ^a +N	235	225	215	205	195	360	360	360	340	25	23
E275	1.0225	+AR or ^a +N	275	265	255	245	235	410	410	410	380	22	20
E315	1.0236	+AR or ^a +N	315	305	295	280	270	450	450	450	420	21	19
E355	1.0580	+AR or ^a +N	355	345	335	315	295	490	490	490	470	20	18
E470	1.0536	+AR	470	430	-	-	-	650	600	-	-	17	15
NOTE l = longitudinal, t = transverse.													
^a At the manufacturers discretion as rolled or normalized.													
^b 1 MPa = 1 N/mm ² .													

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Table 9 — Mechanical properties for tubes made of steels in accordance with Table 4

Steel grade		Delivery condition	Minimum tensile properties										Impact properties		
Steel name	Steel number		Yield strength (R_{eH})					Tensile strength (R_m)				Elongation A		Minimum average absorbed energy, KV min., J at a test temperature of $-20\text{ }^{\circ}\text{C}$	
			MPa					MPa				%			
			For T in mm					For T in mm				l	t	l	t
≤ 16	> 16 ≤ 40	> 40 ≤ 65	> 65 ≤ 80	> 80 ≤ 100	≤ 16	> 16 ≤ 40	> 40 ≤ 65	> 65 ≤ 100							
E275K2	1.0456	+N	275	265	255	245	235	410	410	410	380	22	20	40	27
E355K2	1.0920	+N	355	345	335	315	295	490	490	470	470	20	18	40	27
E420J2	1.0599	+N	420	400	390	370	360	600	560	530	500	19	17	27	20
E460K2	1.8891	+N	460	440	430	410	390	550	550	550	520	19	17	40	27
E590K2	1.0644	+QT	590	540	480	455	420	700	650	570	520	16	14	40	27
E730K2	1.8893	+QT	730	670	620	580	540	790	750	700	680	15	13	40	27
NOTE l = longitudinal, t = transverse.															

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Table 10 — Mechanical properties for tubes made of steels in accordance with Table 5 in delivery condition +N

Steel grade		Minimum tensile properties											
Steel name	Steel number	Yield strength (R_{eH})			Tensile strength (R_m)			Elongation A					
		MPa			MPa			%					
		For T in mm			For T in mm			For T in mm					
		≤ 16	> 16 ≤ 40	> 40 ≤ 80	≤ 16	> 16 ≤ 40	> 40 ≤ 80	≤ 16	> 16 ≤ 40		> 40 ≤ 80		
								l	t	l	t	l	t
C22E	1.1151	240	210	210	430	410	410	24	22	25	23	25	23
C35E	1.1181	300	270	270	550	520	520	18	16	19	17	19	17
C45E	1.1191	340	305	305	620	580	580	14	12	16	14	16	14
C60E	1.1221	390	350	340	710	670	670	10	8	11	9	11	9
38 Mn 6	1.1127	400	380	360	670	620	570	14	12	15	13	16	14
NOTE l = longitudinal, t = transverse.													

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Table 11 — Mechanical properties for tubes made of steels in accordance with Table 5 in delivery condition +QT

Steel grade		Minimum tensile properties															
Steel name	Steel number	Yield strength (R_{eH})				Tensile strength (R_m)				Elongation A							
		MPa				MPa				%							
		For T in mm				For T in mm				For T in mm							
		≤ 8	> 8 ≤ 20	> 20 ≤ 50	> 50 ≤ 80	≤ 8	> 8 ≤ 20	> 20 ≤ 50	> 50 ≤ 80	≤ 8		> 8 ≤ 20		> 20 ≤ 50		> 50 ≤ 80	
										l	t	l	t	l	t	l	t
C22E	1.1151	340	290	270	260	500	470	440	420	20	18	22	20	22	20	22	20
C35E	1.1181	430	380	320	290	630	600	550	500	17	15	19	17	20	18	20	18
C45E	1.1191	490	430	370	340	700	650	630	600	14	12	16	14	17	15	17	15
C60E	1.1221	580	520	450	420	850	800	750	710	11	9	13	11	14	12	14	12
38 Mn 6	1.1127	620	570	470	400	850	750	650	550	13	11	14	12	15	13	16	14
NOTE		l = longitudinal, t = transverse.															

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Table 12 — Mechanical properties for tubes made of steels in accordance with Table 6 in delivery condition +QT

Steel grade		Minimum tensile properties															
Steel name	Steel number	Yield strength (R_{eH})				Tensile strength (R_m)				A							
		MPa				MPa				%							
		For T in mm				For T in mm				For T in mm							
		≤ 8	> 8 ≤ 20	> 20 ≤ 50	> 50 ≤ 80	≤ 8	> 8 ≤ 20	> 20 ≤ 50	> 50 ≤ 80	≤ 8		> 8 ≤ 20		> 20 ≤ 50		> 50 ≤ 80	
										l	t	l	t	l	t	l	t
41 Cr 4	1.7035	800	660	560	-	1 000	900	800	-	11	9	12	10	14	12	-	-
25 Cr Mo 4	1.7218	700	600	450	400	900	800	700	650	12	10	14	12	15	13	16	14
30 Cr Mo 4	1.7216	750	630	520	480	950	850	750	700	12	10	13	11	14	12	15	13
34 Cr Mo 4	1.7220	800	650	550	500	1 000	900	800	750	11	9	12	10	14	12	15	13
42 Cr Mo 4	1.7225	900	750	650	550	1 100	1 000	900	800	10	8	11	9	12	10	13	11
36 Cr Ni Mo 4	1.6511	900	800	700	600	1 100	1 000	900	800	10	8	11	9	12	10	13	11
30 Cr Ni Mo 8	1.6580	1 050	1 050	900	800	1 250	1 250	1 100	1 000	9	7	9	7	10	8	11	9
11 Ni Cr Mo 7-3-2	1.6563	950	870	800	750	1 150	1 050	1 000	900	9	7	10	8	11	9	12	10

JOTE l = longitudinal, t = transverse.

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Table 13 — Impact properties ^a for tubes made of steels, in accordance with Tables 5 and 6 in delivery condition +QT

Steel grade		Minimum average absorbed energy KV_{min} , J, at a test temperature of 20 °C						
Steel name	Steel number	$T \leq 8$	$8 < T \leq 20$		$20 < T \leq 60$		$60 < T \leq 100$	
		l	l	t	l	t	l	t
C22E	1.1151	50	50	32	40	27	40	27
C35E	1.1181	35	35	22	35	22	35	22
C45E	1.1191	25	25	14	25	14	25	14
38Mn6	1.1127	36	40	25	40	25	-	-
41Cr4	1.7035	30	35	22	35	22	-	-
25CrMo4	1.7218	45	50	32	50	32	45	27
30CrMo4	1.7216	40	45	27	45	27	45	27
34CrMo4	1.7220	35	40	25	45	27	45	27
42CrMo4	1.7225	30	35	22	35	22	35	22
36CrNiMo4	1.6511	35	40	25	45	27	45	27
30CrNiMo8	1.6580	30	30	20	35	22	45	27
41NiCrMo7-3-2	1.6563	35	40	25	45	27	45	27
NOTE l = longitudinal, t = transverse.								
^a only applicable when option 5 is specified (see 8.3.5).								

8.4 Hardness requirements

8.4.1 For tubes made of steel grades in Tables 5, 6 and Table A.1 and supplied in the annealed condition and for tube made of steel grades in Table A.1 and supplied in the +TH or +FP condition the hardness requirements in Table C.1 apply.

8.4.2 When Option 6 is specified, for grades of Table 5 and 6 in +QT condition, an agreed hardness range shall apply.

Option 6 An agreed hardness range shall apply and be verified and the results reported (see 11.4).

8.4.3 When Option 7 is specified, for steel grades of Table A1 in +N condition, a hardness test shall be carried out and the results reported.

Option 7 A hardness test shall be carried out and the results reported.

8.5 Hardenability

When Option 8 is specified for steel grades in Tables 5, 6 and for the alloy special steels in Table A.1, the hardenability requirements in Annex D shall apply, except for the +QT condition.

Option 8 Hardenability requirements of Annex D shall apply.

When Option 9 or Option 10 is specified the hardenability shall be verified.

Option 9 Hardenability in accordance with annex D shall be verified at the manufacturers discretion either by calculation or by test in accordance with EN ISO 642 and the results reported.

Option 10 Hardenability shall be verified by a test in accordance with EN ISO 642 and the results reported.

8.6 Appearance and soundness

8.6.1 Appearance

8.6.1.1 The tube shall be free from external and internal surface defects that can be established by visual inspection.

8.6.1.2 The internal and external surface finish of the tubes shall be typical of the manufacturing process and, where applicable, the heat treatment employed. The finish and surface condition shall be such that any surface imperfections requiring dressing can be identified.

8.6.1.3 It shall only be permissible to remove surface imperfections, by grinding or machining, provided that, after so doing the tube thickness in the dressed area is not less than the specified minimum wall thickness. All dressed areas shall blend smoothly into the contour of the tube.

8.6.1.4 Surface imperfections which encroach on the minimum wall thickness shall be considered defects and tubes containing these shall be deemed not to conform to this Part of this European Standard.

8.6.2 Soundness

When Option 11 is specified tubes, supplied with specific inspection and testing shall be subjected to non-destructive testing for imperfections.

Option 11 The full length of the tube shall be non-destructively tested in accordance with 11.6.

When Option 12 is specified, tubes supplied with specific inspection and testing, shall be subjected to a leak tightness test.

Option 12 Leak tightness testing shall be carried out in accordance with 11.5.

8.7 Straightness

The deviation from straightness of tubes with an outside diameter D equal to or greater than 33,7 mm shall not exceed $0,0015 L$ (L = Length of the tube). The deviation from straightness, for tubes with D less than 33,7 mm, is not specified.

NOTE The deviation from straightness for tube with $D < 33,7$ mm is not specified, due to bending during processing and subsequent handling, however tube should be reasonably straight.

8.8 End preparation

Tubes shall be delivered with square cut ends. The ends shall be free from excessive burrs.

8.9 Dimensions, masses, tolerances and sectional properties

8.9.1 Outside diameters, wall thicknesses and masses

Preferred outside diameters and wall thicknesses have been selected from EN 10220 and together with additional diameters are given in Table 14.

The masses for these dimensions are given in EN 10220 or shall be calculated using the formulae in Annex E.

NOTE Dimensions which are not included in Table 14 may be agreed at the time of enquiry and order.

EN 10297-1:2003 (E)**8.9.2 Length**

The tubes shall be delivered in random lengths, unless Option 13 is specified. The length range may be agreed at the time of enquiry and order.

Option 13 Exact lengths shall be supplied. The length required shall be specified at the time of enquiry and order.

8.9.3 Tolerances**8.9.3.1 Tolerances on outside diameter (D) and wall thickness (T)**

The outside diameter and wall thickness of the tubes shall be within the tolerance limits given in Table 15.

Out of roundness is included in the tolerances on outside diameter and eccentricity is included in the tolerances on thickness.

Table 14 — Preferred dimensions of seamless steel tubes

[illegible]

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Table 14 — Preferred dimensions of seamless steel tubes *(continued)*

Dimensions in mm

D Outside diameter	T Wall thickness							
	50	55	60	65	70	80	90	100
177,8								
193,7								
203								
219,1								
229								
244,5								
273								
298,5								
323,9								
355,6								
368								
406,4								
419								
457								
508								
521								
559								
610								

Table 15 — Tolerances on outside diameter and on thickness

Outside diameter D mm	Tolerances on D	Tolerances on T for a T/D ratio		
		$\leq 0,025$	$> 0,025$ $\leq 0,050$	$> 0,050$
$D \leq 219,1$	$\pm 1\%$ or $\pm 0,5$ mm whichever is the greater	$\pm 12,5\%$ or $\pm 0,4$ mm whichever is the greater		
$D > 219,1$	$\pm 1\%$	$\pm 20\%$	$\pm 15\%$	$\pm 12,5\%$

8.9.3.2 Tolerances on exact length

The limit deviations shall be as given in Table 16.

Table 16 — Tolerances on Exact Lengths

Dimensions in mm

Length L mm	Tolerance mm
$\leq 6\,000$	+10 0
$6\,000 < L \leq 12\,000$	+15 0
$> 12\,000$	0/+ by agreement

8.9.4 Sectional properties

The nominal sectional properties shall be calculated in accordance with Annex E.

9 Inspection

9.1 Types of inspection

The conformity to the requirements of the order for tubes supplied in accordance with this Part of this European Standard shall be checked by:

- non-specific inspection and testing (see EN 10021) for tubes made of steels available in Table 3 except grade E470, unless Option 14 is specified ;

Option 14 Tubes made of steels in accordance with Table 3 shall be supplied with specific inspection and testing.

- specific inspection and testing (see EN 10021) for tubes made of steel grade E470 and steels in accordance with Tables 4, 5, 6 and Table A.1.

9.2 Inspection documents

9.2.1 Types of inspection documents

The following inspection documents, in accordance with EN 10204, shall be issued :

- certificate of compliance with order 2.1 for tubes supplied with non-specific inspection and testing unless Option 15 is specified ;

Option 15 Inspection document type 2.2 shall be supplied.

- inspection certificate 3.1.B, for tubes supplied with specific inspection and testing unless Option 16 is specified.

Option 16 Inspection document 3.1.A, 3.1.C or 3.2 shall be supplied, the type of document to be specified by the purchaser.

If an inspection document 3.1.A, 3.1.C or 3.2 is specified the purchaser shall notify the manufacturer of the name and address of the organisation or person who is to carry out the inspection and produce the inspection document. In the case of inspection report 3.2 it shall be agreed which party issue the certificate.

9.2.2 Content of inspection documents

The content of the inspection document shall be in accordance with prEN 10168 as shown in 9.2.2.1, 9.2.2.2 and 9.2.2.3.

9.2.2.1 For tubes supplied with non-specified inspection and testing the certificate of compliance with the order shall contain the following codes and information:

- | | |
|---|---|
| A | commercial transactions and parties involved; |
| B | description of products to which the inspection document applies; |
| Z | validation. |

9.2.2.2 For tubes supplied with non-specific inspection and testing and a test report type 2.2 it shall contain the following codes and information :

- | | |
|-----|---|
| A | commercial transactions and parties involved; |
| B | description of products to which the inspection document applies; |
| C02 | direction of test pieces; |

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C10 to C13 tensile test;

C71 to C92 chemical composition;

D01 marking and identification, surface appearance, shape and dimensional properties;

Z validation.

9.2.2.3 For tubes supplied with specific inspection and testing the inspection documents 3.1.A, 3.1.B, 3.1.C, 3.2 shall contain the following codes and information :

A commercial transactions and parties involved ;

B description of products to which the inspection document applies ;

C02 to C03 direction of test pieces and test temperature where applicable ;

C10 to C13 tensile test, if applicable ;

C40 to C43 impact test, if applicable ;

C60 to C69 other tests (e.g. options invoked which require test pieces) ;

C71 to C92 chemical composition ;

D01 marking and identification, surface appearance, shape and dimensional properties ;

D02 to D99 for other tests (e.g. options invoked which do not require test (pieces) ;

Z validation.

9.3 Summary of inspection and testing

Inspection and testing shall be carried out as stated in Table 17.

Table 17 — Summary of inspection and testing

Type of inspection and testing		Non-specific inspection and testing	Specific inspection and testing	Reference paragraph
Mandatory	Cast Analysis	Manufacturers procedure	1/cast	8.2
	Tensile test ^a	Manufacturers procedure	1/test unit	8.3, 11.1
	Impact test ^b	Not applicable	1 set/test unit	8.3, 11.2
	Dimensional inspection	See 11.7		
	Visual examination	See 11.8		
	Material identification of alloy steel tubes	Not applicable	Individual	11.9
Optional	Tensile test on heat treated sample ^c	Not applicable	1/cast	8.3.2, 8.3.3
	Tensile test ^d	Not applicable	1/test unit	8.3.4, 11.1
	Impact test ^e	Not applicable	1 set/test unit	8.3.5, 11.2
	Verification of hardness range	Not applicable	According to documented procedure	8.4.2
	Hardness test	Not applicable	1/test unit	8.4.3, 11.4
	Hardenability test	Not applicable	1/cast	8.5, 11.3
	Non-destructive test for imperfections	Not applicable	individual	8.6.2, 11.6
	Leak tightness test	Not applicable	individual	8.6.2, 11.5
^a tensile test is not mandatory for steel grades of tables 5 and 6 in the delivery conditions +A and +AR and for steel grades of Table A.1 (see table 2) ^b Only for steel grades J2 and K2 in Table 4. ^c See Options 2 and 3 and 4 in 8.3. ^d See Option 4 in 8.3. ^e Only for steel grades under the delivery conditions +QT shown in Table 13.				

10 Sampling

10.1 Frequency of tests

10.1.1 Test Unit

In the case of specific inspection a test unit shall comprise tubes of the same steel grade the same specified dimensions, the same cast, the same manufacturing process and the same delivery condition.

The quantity of tubes per test unit shall conform to Table 18.

EN 10297-1:2003 (E)**10.1.2 Number of sample tubes per test unit**

One sample tube shall be taken from each test unit.

Table 18 — Quantity of tubes per test unit

Outside diameter (<i>D</i>) mm	Maximum number of tubes per test unit
$D \leq 114,3$	400
$114,3 < D \leq 323,9$	200
$D > 323,9$	100

10.2 Preparation of samples and test pieces**10.2.1 General**

Samples and test pieces shall be taken at the tube ends and in accordance with the requirements of EN ISO 377.

10.2.2 Test piece for the tensile test

The test piece shall be taken in accordance with the requirements of EN 10002-1.

- For tubes with *D* less than or equal to 219,1 mm, the test piece shall be either a full tube section or a strip section and be taken in a direction longitudinal to the axis of the tube;
- For tubes with *D* greater than 219,1 the test piece is either a machined test piece of circular cross-section from an unflattened sample or a flattened strip section, and shall be taken in a direction either longitudinal or transverse to the axis of the tube.

10.2.3 Test piece for the impact test

The direction of testing is at the discretion of the manufacturer. Flattening of samples is not permitted. Three standard Charpy V-notch test pieces in accordance with EN 10045-1 shall be taken. If the nominal product thickness is such that standard test pieces cannot be produced, the test shall be carried out using test pieces of width less than 10 mm but not less than 5 mm. In all cases, the largest obtainable width shall be used.

Tubes shall not be subject to impact testing where longitudinal test pieces of width 5 mm or greater cannot be obtained.

Test pieces shall be taken and prepared such that the axis of the notch is perpendicular to the surface of the tube.

10.2.4 Test piece for hardenability test (Jominy)

Test pieces shall be prepared in accordance with EN ISO 642.

When a test piece from a thick wall sample tube is used (see Option 17) the axis of the test piece shall be located at a distance of not more than 20 mm from the outside surface.

10.2.5 Test piece for hardness test (Brinell)

Test pieces shall be prepared in accordance with EN ISO 6506-1.

11 Test methods

11.1 Tensile test

The test shall be carried out at room temperature in accordance with EN 10002-1 and the following determined:

- the tensile strength (R_m);
- the upper yield strength (R_{eH});

If a yield phenomenon is not present the 0,2 % proof strength ($R_{p0,2}$) or the 0,5 % proof strength, total extension ($R_{t0,5}$) shall be determined. In case of dispute the 0,2% proof strength ($R_{p0,2}$) shall apply.

- the percentage elongation after fracture with reference to a gauge length of $5,65\sqrt{S_0}$.

If a non-proportional test piece is used, the percentage elongation value shall be converted to the value for a gauge length $L_0 = 5,65\sqrt{S_0}$ using the conversion Tables given in EN ISO 2566-1.

11.2 Impact test

11.2.1 The test shall be carried out in accordance with EN 10045-1. The test temperature shall be - 20 °C for mandatory tests and 20 °C for optional tests (see Table 17).

11.2.2 The mean value of the three test pieces shall meet the specified minimum average value given in Tables 9 and 13. One individual value may be below the specified value, provided that it is not less than 70 % of that value.

11.2.3 If the width (W) of the test piece is less than 10 mm, the measured impact energy (KV_p) shall be converted to impact energy (KV_c) using the following equation.

$$KV_c = \frac{10 KV_p}{W} \quad (1)$$

where

KV_c is the calculated impact energy, in joules;

KV_p is the measured impact energy in joules;

W is the width of the test piece in millimetres.

The calculated impact energy KV_c shall conform to the requirements given in 11.2.2.

11.2.4 If the requirements of 11.2.2 are not met, then an additional set of three test pieces may be taken at the discretion of the manufacturer from the same sample and tested. To consider the test unit as conforming, after testing the second set, the following conditions shall be satisfied simultaneously:

- the average value of six tests shall be equal to or greater than the specified minimum value;
- not more than two of six individual values may be lower than the specified minimum value;
- not more than one of the six individual values may be lower than 70 % of the specified value.

11.2.5 The dimensions in millimetres of test pieces, the measured energy values and the average value shall be reported.

EN 10297-1:2003 (E)**11.3 Hardenability test**

The test shall be carried out in accordance with EN ISO 642 and EN ISO 6508-1:1999 scale C. The test results reported by the steel producer shall apply unless Option 17 is specified for tubes with wall thickness equal or greater than 35 mm.

Option 17 A hardenability test shall be performed on a test piece taken from a sample tube.

11.4 Hardness test

The test shall be carried out in accordance with EN ISO 6506-1, and $HB_{10/3\ 000}$ be determined.

Except for Option 6 (see 8.4.2), where a documented procedure shall be applied, two hardness indentations shall be made and the average shall constitute the test result.

The indentations shall be :

- on either the adequately prepared outside surface at one end of the sample tube;
- or on any appropriate surface of a sample from the test unit intentionally taken or available from tests.

It is permitted to supply tubes that have been used for a hardness test unless Option 18 is specified.

Option 18 Supplied tubes shall not contain areas that have been prepared and used for hardness tests.

11.5 Leak tightness test**11.5.1 General**

The test shall be carried out in accordance with 11.5.2 or 11.5.3. The choice of test method is at the discretion of the manufacturer, unless Option 19 is specified.

Option 19 The test method for verification of leak tightness according to 11.5.2 or 11.5.3 is chosen by the purchaser.

11.5.2 Hydrostatic test

The hydrostatic test shall be carried out at a test pressure of 70 bar or P , calculated from the following equation, whichever is the lower.

$$P = \frac{20\ S\ T}{D} \quad (2)$$

where

- P is the test pressure in bar;
- D is the specified outside diameter (in mm);
- T is the specified wall thickness (in mm);
- S is the stress in MPa corresponding to 70 % of the specified minimum yield strength (see Tables 8, 9, 10, 11 and 12) for the steel grade concerned.

The test pressure shall be held for not less than 5 s for tubes with specified outside diameter less than or equal to 457 mm and for not less than 10s for tubes with specified outside diameter greater than 457 mm.

The tube shall withstand the test without leakage or visible deformation

NOTE This hydrostatic leak tightness test is not a strength test.

11.5.3 Electromagnetic test

The test shall be carried out in accordance with EN 10246-1.

11.6 Non-destructive testing

Testing shall be carried out in accordance with one of the following non-destructive testing standards to the acceptance level indicated:

- EN 10246-3 - acceptance level E4;
- EN 10246-5 - acceptance level F4;
- EN 10246-7 - acceptance level U4 sub-category C for $T \leq 4$ mm and sub-category D for $T > 4$ mm.

The choice of method is at the discretion of the manufacturer.

11.7 Dimensional inspection

Specified dimensions shall be verified.

A gauge is used normally for measuring the outside diameter, however for tubes with D equal to or greater than 406,4 mm this may be measured using a circumference tape. The wall thickness shall be measured at the tube ends.

11.8 Visual examination

Tubes shall be visually examined for compliance with the requirement of 8.6.1.

11.9 Material identification

Each tube from alloy steel in the Tables 6 and Table A.1 shall be tested to assure that the correct grade is being supplied.

11.10 Retests, sorting and reprocessing

For retests, sorting and reprocessing the requirements of EN 10021 shall apply.

12 Marking

12.1 Except as provided for in 12.2, each tube shall be marked by suitable and durable methods such as painting, stamping, adhesive labels or attached tags with the following:

- the manufacturers name or trademark;
- the number of this Part of this European Standard (EN 10297-1);
- the steel name, e.g. E275;
- the symbol for the delivery condition, see Table 2, except for the condition +AR for grades in Table 3;
- the symbol +H and the cast number for tubes supplied against a hardenability requirement (see 8.5);

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- in the case of specific inspection, the mark of the inspection representative and an identification number (e.g. order or item number) which permits the correlation of the product or delivery unit to the related document.

Example of marking :

X-EN 10297-1 - C15R+FP - Y - Z

X is the manufacturers name or trademark

Y is the mark of inspection representative

Z is the identification number (e.g. order or item number)

12.2 Where the products are supplied bundled, the marking required in 12.1 may be on a label which shall be securely attached to the bundle. Additionally the label or tags shall identify the diameter, wall thickness and type of length of the tube.

13 Protection

The tubes shall be delivered without temporary corrosion protection unless Option 20 is specified.

Option 20 Tubes shall be specially protected for transit and storage. The type of coating shall be agreed at the time of enquiry and order.

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Annex A
(normative)

Steels for case hardening

Table A.1 — Chemical composition (cast analysis) in % by mass

Steel grade		C		Si	Mn		P	S		Cr		Mo		Ni	
Steel name	Steel number	min.	max.	max.	min.	max.	max.	min.	max.	min.	max.	min.	max.	min.	max.
C10E	1.1121	0,07	0,13	0,40	0,30	0,60	0,035	-	0,035	-	-	-	-	-	-
C15E	1.1141	0,12	0,18	0,40	0,30	0,60	0,035	-	0,035	-	-	-	-	-	-
C15R	1.1140	0,12	0,18	0,40	0,30	0,60	0,035	0,020	0,040	-	-	-	-	-	-
16 Mn Cr 5	1.7131	0,14	0,19	0,40	1,00	1,30	0,035		0,035	0,80	1,10	-	-	-	-
16 Mn Cr S 5	1.7139	0,14	0,19	0,40	1,00	1,30	0,035	0,020	0,040	0,80	1,10	-	-	-	-
20 Ni Cr Mo 2-2	1.6523	0,17	0,23	0,40	0,65	0,95	0,035	-	0,035	0,35	0,70	0,15	0,25	0,40	0,70
20 Ni Cr Mo S 2-2	1.6526	0,17	0,23	0,40	0,65	0,95	0,035	0,020	0,040	0,35	0,70	0,15	0,25	0,40	0,70

Annex B
(informative)

Recommended heat treatment temperatures

Table B.1 — Recommended heat treatment temperatures in °C for steels in Table A.1

Steel grade		Heat Treatment for the delivery condition			
Steel name	Steel number	+A	+TH	+FP	+N
C10E	1.1121	650 to 700	-	-	900 to 920
C15E	1.1141	650 to 700	-	-	890 to 920
C15R	1.1140	650 to 700	-	-	890 to 920
16 Mn Cr 5	1.7131	650 to 700	850 to 950	900 to −1 000	840 to 870
16 Mn Cr S 5	1.7139	650 to 700	850 to 950	900 to −1 000	840 to 870
20 Ni Cr Mo 2-2	1.6523	650 to 700	850 to 950	900 to −1 000	850 to 880
20 Ni Cr Mo S 2-2	1.6526	650 to 700	850 to 950	900 to −1 000	850 to 880

Table B.2 — Recommended heat treatment temperatures °C for steels in Tables 3, 4, 5 and 6

Steel grade		Heat treatment			
Steel name	Steel number	Anneal	Normalize	Austenitize ^a	Temper
E235	1.0308	-	880 to 940	-	-
E275	1.0225	-	880 to 940	-	-
E315	1.0236	-	890 to 950	-	-
E355	1.0580	-	900 to 960	-	-
E275K2	1.0456	-	880 to 940	-	-
E355K2	1.0920	-	900 to 960	-	-
E420J2	1.0599		900 to 960		
E460K2	1.8891	-	880 to 950	-	-
E590K2	1.0644			900 to 960	580 to 680
E730K2	1.8893	-	-	910 to 950	550 to 680
C22E	1.1151	650 to 700	880 to 920	860 to 900 ^b	550 to 680
C35E	1.1181	650 to 700	860 to 900	840 to 880	550 to 680
C45E	1.1191	650 to 700	840 to 880	820 to 860	550 to 680
C60E	1.1221	650 to 700	820 to 860	800 to 840	550 to 680
38Mn6	1.1127	650 to 700	850 to 880	820 to 850	540 to 680
41Cr4	1.7035	680 to 720	840 to –880 ^c	820 to 860	540 to 680
25CrMo4	1.7218	680 to 720	860 to –900 ^c	840 to 880	540 to 680
30CrMo4	1.7216	680 to 720	860 to –900 ^c	840 to 870	540 to 680
34CrMo4	1.7220	680 to 720	850 to –890 ^c	830 to 870	540 to 680
42CrMo4	1.7225	680 to 720	840 to –880 ^c	820 to 860	540 to 680
36CrNiMo4	1.6511	650 to 700	850 to –880 ^c	820 to 850	540 to 680
30CrNiMo8	1.6580	650 to 700	850 to –880 ^c	830 to –860 ^d	540 to 680
41NiCrMo7-3-2	1.6563	650 to 700	860 to –890 ^c	840 to 870	530 to 680
^a Unless otherwise stated temperatures are for water quenching and have to be increased by 10 °C for oil quenching. ^b Only water quenching. ^c These temperatures apply when normalizing is carried out prior to quenching and tempering. ^d Only oil quenching.					

Annex C (normative)

Hardness requirements for heat treated tubes

Table C.1 — Brinell hardness requirements for tubes in delivery condition +A, +TH or +FP

Steel grade		Brinell hardness in delivery condition				
Steel name	Steel number	+A	+TH		+FP	
			min.	max.	min.	max.
C22E	1.1151	156	-	-	-	-
C35E	1.1181	183	-	-	-	-
C45E	1.1191	207	-	-	-	-
C60E	1.1221	241	-	-	-	-
38Mn6	1.1127	223	-	-	-	-
41Cr4	1.7035	241	-	-	-	-
25CrMo4	1.7218	212	-	-	-	-
30CrMo4	1.7216	223	-	-	-	-
34CrMo4	1.7220	223	-	-	-	-
42CrMo4	1.7225	241	-	-	-	-
36CrNiMo4	1.6511	241	-	-	-	-
30CrNiMo8	1.6580	245	-	-	-	-
41NiCrMo7-3-2	1.6563	248	-	-	-	-
C10E	1.1121	131	-	-	-	-
C15E	1.1141	143	-	-	-	-
C15R	1.1140	143	-	-	-	-
16MnCr5	1.7131	207	156	207	140	187
16MnCrS5	1.7139	207	156	207	140	187
20NiCrMo2-2	1.6523	212	161	212	149	194
20NiCrMoS2-2	1.6526	212	161	212	149	194

Annex D
(normative)

Hardenability - Limiting values for C scale Rockwell

Table D.1 — Non-alloy special steels

Steel grade		Limits of range for distance in mm from the quenched end																
		HRC hardness																
Steel name	Steel number		1	2	3	4	5	6	7	8	9	10	11	13	15	20	25	30
C35E	1.1181	max.	58	57	55	53	49	41	34	31	28	27	26	25	24	23	20	-
		min.	48	40	33	24	22	20	-	-	-	-	-	-	-	-	-	
C45E	1.1191	max.	62	61	61	60	57	51	44	37	34	33	32	31	30	29	28	27
		min.	55	51	37	30	28	27	26	25	24	23	22	21	20	-	-	-
C60E	1.1221	max.	67	66	65	63	62	59	54	47	39	37	36	35	34	33	31	30
		min.	60	57	50	39	35	33	32	31	30	29	28	27	26	25	23	21
38 Mn6	1.1127	max.	58 ^a	-	57	-	55	-	51	-	47	-	42	37	34	31	29	-
		min.	51 ^a	-	47	-	40	-	33	-	27	-	23	21	20		-	-
^a Distance 1,5 mm from quenched end.																		

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Table D.2 — Alloy special steels

Steel grade		Limits of range for distance in mm from the quenched end HRC hardness															
Steel name	Steel number		1.5	3	5	7	9	11	13	15	20	25	30	35	40	45	50
41Cr4	1.7035	max.	61	61	60	59	58	56	54	52	46	42	40	38	37	36	35
		min.	53	52	50	47	41	37	34	32	29	26	23	21	-	-	-
25CrMo4	1.7218	max.	52	52	51	50	48	46	43	41	37	35	33	32	31	31	31
		min.	44	43	40	37	34	32	29	27	23	21	20	-	-	-	-
30CrMo4	1.7216	max.	56	55	54	50	48	45	40	39	35	33	33	31	31	30	29
		min.	49	46	43	35	32	29	26	26	24	23	22	-	-	-	-
34CrMo4	1.7220	max.	57	57	57	56	55	54	53	52	48	45	43	41	40	40	39
		min.	49	49	48	45	42	39	36	34	30	28	27	26	25	24	24
42CrMo4	1.7225	max.	61	61	61	60	60	59	59	58	56	53	51	48	47	46	45
		min.	53	53	52	51	49	43	40	37	34	32	31	30	30	29	29
36CrNiMo4	1.6511	max.	59	59	58	58	57	57	57	56	55	54	53	52	51	50	49
		min.	51	50	49	49	48	47	46	45	43	41	39	38	36	34	33
30CrNiMo8	1.6580	max.	56	56	56	56	55	55	55	55	55	54	54	54	54	54	54
		min.	48	48	48	48	47	47	47	46	46	45	45	44	44	43	43
40NiCrMo7-3-3	1.6563	max.	60	60	60	60	60	60	60	60	59	58	58	57	57	56	56
		min.	53	53	53	53	53	53	52	52	49	47	46	44	43	42	40

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Table D.3 — Alloy special steels for case hardening

Steel grade		Limits of range for distance in mm from the quenched end													
		HRC hardness													
Steel name	Steel number		1.5	3	5	7	9	11	13	15	20	25	30	35	40
16MnCr5	1.7131	max.	47	46	44	41	39	37	35	33	31	30	29	28	27
16MnCrS5	1.7139	min.	39	36	31	26	24	21	-	-	-	-	-	-	-
20NiCrMo2-2	1.6523	max.	49	48	45	42	36	33	31	30	27	25	24	24	23
20NiCrMoS2-2	1.6526	min.	41	37	31	25	22	20	-	-	-	-	-	-	-

Annex E (normative)

Formulae for calculation of nominal section properties

The nominal sectional properties for tubes are calculated from the following geometric properties using the formulae given as follows:

Specified outside diameter	D	(in mm)
Specified thickness	T	(in mm)
Calculated inside diameter	$d = D - 2T$	(in mm)
Superficial area/unit length	$A_s = \frac{\pi D}{10^3}$	(in m ² /m)
Cross sectional area	$A = \frac{\pi(D^2 - d^2)}{4 \cdot 10^2}$	(in cm ²)
Mass per length	$M = 0,785 A$	(in kg/m)
Second moment of area	$I = \frac{\pi(D^4 - d^4)}{64 \cdot 10^4}$	(in cm ⁴)
Radius of gyration	$i = \sqrt{\frac{I}{A}}$	(in cm)
Elastic section modulus	$W_{el} = \frac{2I \cdot 10}{D}$	(in cm ³)
Plastic section modulus	$W_{pl} = \frac{D^3 - d^3}{6 \cdot 10^3}$	(in cm ³)
Torsional Inertia constant (polar moment of inertia)	$I_t = 2I$	(in cm ⁴)
Torsional modulus constant	$C_t = 2W_{el}$	(in cm ³)

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